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Form Approved OMB No. 0704-0188

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3. REPORT TYPE AND DATES COVERED

Final Report, 1 Nov 88 to 31 Oct 89

4. TITLE AND SUBTITLE

DEVELOPMENT OF PROBABILISTIC AND POSSEBILISTIC APPROACHES TO APPROXIMATE REASONING AND ITS APPLICATIONS

945

5. FUNDING NUMBERS

AFOSR-89-0084 61102F 2304/A7

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8. PERFORMING ORGANIZATION REPORT NUMBER

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AFOSR-TR- 190 - U 394

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

AFOSR/NM Building 410 Bollling AFB, DC 20332-6448 10. SPONSORING/MONITORING AGENCY REPORT NUMBER

AFOSR-89-0084

11. SUPPLEMENTARY NOTES

12b. DISTRIBUTION CODE

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. ABSTRACT (Maximum 200 words)

The research has been focused in the main on the development of fuzzy logic and its applications in three problem areas: (a) qualitative systems analysis; (b) imprecise knowledge representation; and (c) neural network control of fuzzy rule-based systems. These problem areas are of direct relevance to the analysis and design of both control and knowledge-based systems which operate in an environment of uncertainty or imprecision. In the realm of qualitative systems analysis, a basic problem which we have studied is the following. Assume that a system is comprised of an interconnection of n components, with the qualitative input-output relation of each component characterized by a collection of fuzzy it-then rules involving linguistic variables. The problem is to compute the qualitative input-output relation of the system from the specifications of the qualitative input-output relations of its components. An effective solution to this problem has been obtained through the use of what might be called FA-Prolog. FA-Prolog is a subset of Fuzzy Prolog in which the certainty factors are assumed to be equal to one. With this simplifying assumption, the fuzzy if then rules can be handled in a straight-forward way and the determination of the qualitative input-output relation reduces to the execution of an FA-Prolog program.

14 SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

UNCLASSIIFED

·UNCLASSIFIED

UNCLASSIFIED

Standard Form 298 (Rev. 2-89)

NSN 7540-01-280-5500

# Final Report AFOSR Grant No. AFOSR-89-0084

## Development of Probabilistic and Possibilistic Approaches to Approximate Reasoning and Its Applications

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### SUMMARY

Our research has been focused in the main on the development of fuzzy logic and its applications in three important problem areas: (a) qualitative systems analysis; (b) imprecise knowledge representation; and (c) neural network control of fuzzy rule-based systems. These problem areas are of direct relevance to the analysis and design of both control and knowledge-based systems which operate in an environment of uncertainty or imprecision.

In the realm of qualitative systems analysis, a basic problem which we have studied is the following. Assume that a system is comprised of an interconnection of n components, with the qualitative input-output relation of each component characterized by a collection of fuzzy if-then rules involving linguistic variables. (A simple example of such a rule might be: if the pressure is high then the volume is low.) The problem is to compute the qualitative input-output relation of the system from the specifications of the qualitative input-output relations of its components.

An effective solution to this problem may be obtained through the use of what might be called FA-Prolog. FA-Prolog is a subset of Fuzzy Prolog in which the certainty factors are assumed to be equal to one. With this simplifying assumption, the fuzzy ifthen rules can be handled in a straight-forward way and the determination of the qualitative input-output relation reduces to the execution of an FA-Prolog program.

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In the realm of imprecise knowledge representation, we have focused our attention on the representation of commonsense knowledge. The basic idea underlying our approach is that such knowledge may be assumed to consist of a collection of dispositions: that is, propositions which are preponderantly but not necessarily always true. Unlike the approaches which have become popular in AI (circumscription, non-monotonic reasoning, and default reasoning), our approach is based on fuzzy logic and, more specifically, on the theory of usuality.

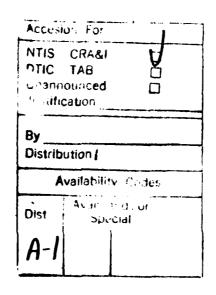
In the realm of neural networks, a doctoral student, C.C. Lee, has opened a new direction with the development of a self-learning fuzzy control system which is tuned by a neural network. Simulation studies involving a pole-balancing system have shown that Lee's system learns significantly faster than the systems described in the literature and is substantially more robust.

It should be noted that fuzzy logic is finding its way into a wide variety of commercial products ranging from automobile transmissions and autofocus cameras to VLSI chip design and robot eyes. A representative sample of such applications is included in the Appendix.

### Work credited to AFOSR 89-0084

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UCB/ERL M89/104

